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14. ABSTRACT

Research results are typically reported using 2-dimensional methods that include tables, figures, and charts. With the availability of 3-dimensional (3D) visualization applications, based on the Virtual Reality Modeling Language (VRML) and Extensible 3D (X3D) graphics, the Naval Research Laboratory (NRL) has employed alternative methods of information presentation. These 3D applications are displayed with viewer software on conventional Internet web-browsers and may be effectively used in oral presentations and for separate viewing on the Internet. NRL has used VRML and X3D to create visualizations that enhance its reporting. This paper describes 3D applications that were developed to visualize Marine Corps Amphibious Assault Vehicle (AAV) navigation performances during field demonstrations and augment the 2-dimensional performance data. They depict steering patterns used to avoid surface waves, how well the drivers negotiate lane turning points, and a vehicle's vulnerability to mines and other dangers (e.g., subsurface rocks) when steered outside of the cleared navigation lanes.

15. SUBJECT TERMS:
3-dimensional (3D) visualization, Amphibious Assault Vehicle, navigation

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3-DIMENSIONAL ENHANCEMENTS FOR VISUALIZING LANE NAVIGATION PERFORMANCE

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Research results are typically reported using 2-dimensional (2D) methods that include tables, figures, and charts. With the availability of 3-dimensional (3D) visualization applications, based on the Virtual Reality Modeling Language (VRML) and Extensible 3D (X3D) graphics, the Naval Research Laboratory (NRL) has employed alternative methods of information presentation. These 3D applications are displayed with viewer software on conventional Internet web-browsers and may be effectively used in oral presentations and for separate viewing on the Internet. This paper describes 3D applications that were developed to visualize Marine Corps Amphibious Assault Vehicle (AAV) navigation performances during field demonstrations and augment the 2D performance data. They depict steering patterns used to avoid surface waves, how well the drivers negotiate lane turning points, and a vehicle's vulnerability to mines and other dangers (e.g., subsurface rocks) when steered outside the cleared navigation lanes.

Keywords: 3D Visualization; Amphibious Assault Vehicle; Navigation

INTRODUCTION

Amphibious landing operations conducted in a mined environment require assault lanes that are either cleared of mines or designed to avoid mined areas. Lane width is largely determined by the ability of AAVs to precisely navigate within lanes. Therefore, assault vehicles with more accurate navigation capabilities support reduced lane clearance requirements. To this end, NRL was tasked to develop, test and demonstrate a prototype moving-map system that facilitates lane navigation improvements for AAVs and subsequently report its findings to sponsoring program offices. NRL proposed that a moving-map would improve crew situational awareness and communications, compared with using conventional navigation methods, thereby improving precise lane navigability (Gendron, Myrick, Edwards, & Mang, 2002). Several demonstrations were performed over the past two years, notably Fleet Battle Experiment Juliet in July 2002 and Transparent Hunter in January 2003 (TH03). Comparisons in navigation performance were measured in terms of cross-track error for vehicles using the moving-map system and the same vehicles using no moving-map as they navigated through a designated course (Lohrenz, Edwards, Myrick, Gendron, Trenchard, 2003). NRL has developed 3D visualization applications to enhance its reporting of these demonstration results. These applications are displayed with Cortona VRML Client viewer software on conventional Internet web-browsers (e.g., Netscape and MS Explorer); many other viewers are free and available for download on the Internet. Each visualization depicts a beach and ocean scenario with an animated 3D AAV model navigating through a planned course using actual track data that was recorded as a series of latitude and longitude points.

METHOD

The visualizations were designed to augment 2D data that were collected during TH03 demonstrations. Test runs that could reveal significant navigation issues (e.g., to compare navigation performance using different navigation aids) were selected for 3D visualization. Latitude and longitude coordinates were originally recorded every second during navigation runs. However, since AAVs typically travel at 6 knots or less, these data sets tended to be rather large and subsequently required long application initialization

times. With such a high collection rate, it was possible to downsample the original data and still maintain essential visual information. Consequently, every fourth coordinate set was used during downsampling, resulting in an AAV position displayed for every 4 seconds of original run time. Data set sizes were reduced 75% and initialization times were reasonably brief.

3D military models have been developed using X3D graphics at the Naval Post-Graduate School's Scenario Authoring and Visualization for Advanced Graphical Environments (SAVAGE) group and are available through their website. NRL selected the SAVAGE AAV model and modified it to include a windowed driver's hatch (Fig. 1). The SAVAGE group Waypoint Interpolator code was modified and used for AAV animation. The NRL visualization software includes downsampled test run data and modified SAVAGE code to create re-enactments of actual navigation performance during TH03 demonstrations.

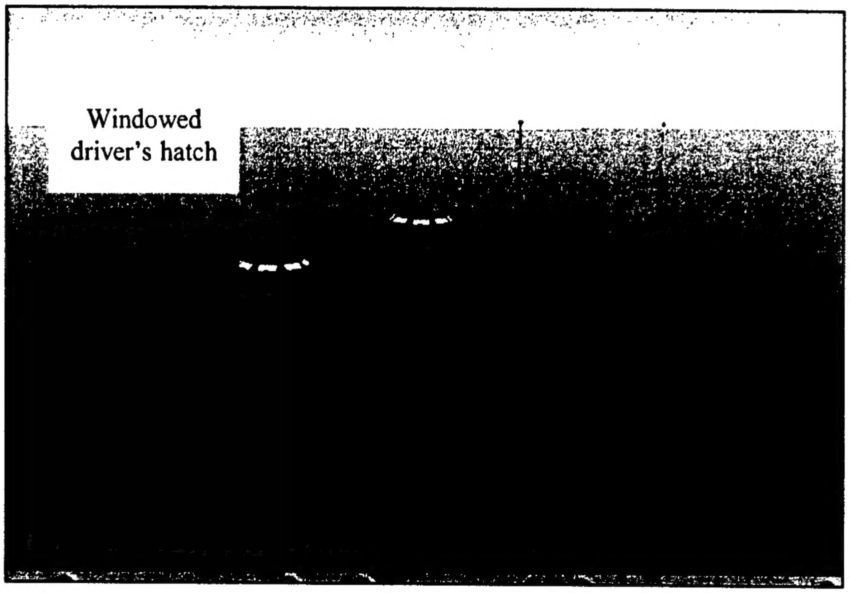

Figure 1. The AAV model modified to include a windowed driver's hatch.

The re-created demonstration area is deliberately depicted with simple beach and ocean regions since the visualizations are intended to focus solely on AAV navigation performance. These regions were created using rectangular objects with texture overlays. During the test runs, AAV drivers were instructed to navigate along a predetermined route; the 3D visualizations include this route drawn in white and the AAV's actual course drawn in red. During animation, downsampled latitude and longitude data are used to depict the AAV traveling on its actual course.

In VRML, viewpoints can be created to provide different perspectives on the scene of interest (Ames, Nadeau, Moreland, 1997). Two different full-scene designs were produced for these visualizations. The default viewpoint is an exocentric perspective view, which gives an impression of looking at the scene from a raised and angled distance (e.g., Fig. 2 and Fig. 3). A second viewpoint looks directly down on the course from above (i.e., plan view, Fig. 4). Two additional viewpoints designed as part of the original AAV model include riding from the rear of the AAV and riding on the front of the AAV.

RESULTS

Navigation runs that illustrate significant navigation problems or interesting observations were selected for visualization. For example, figure 2 depicts a typical back-and-forth steering pattern used by drivers to avoid submersion of the AAV under surface waves and also shows how well this particular driver negotiated lane turning points. The run in figure 2 was navigated with the driver using a moving-map system. AAVs that did not navigate with a moving-map relied instead on a Precision Lightweight Global Positioning System (GPS) Receiver (PLGR), which simply displays vehicle location as latitude and longitude coordinates on the display of a small handheld device. Drivers tended to miss their course waypoints more often with the PLGR (figure 3) than with the moving-map. Missed waypoints always resulted in steering out of the navigation lane, which in a true operational situation, would leave a vehicle perilously vulnerable to mines and other threats. Furthermore, AAV crews were often unaware of their error and misjudged their location and ensuing vulnerability.

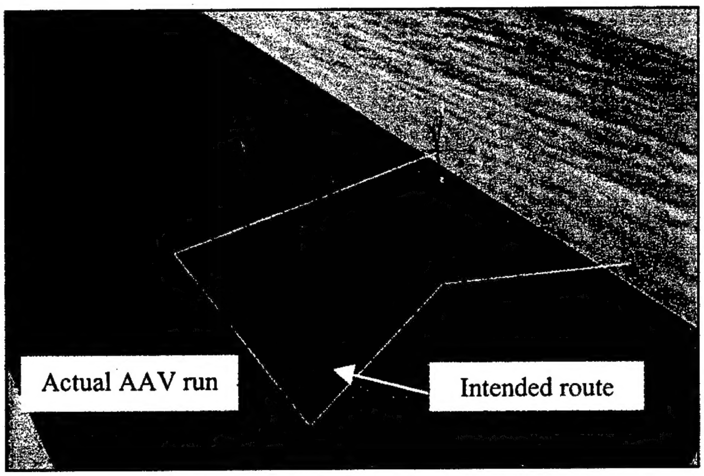

Figure 2. AAV steering patterns used to avoid surface waves.

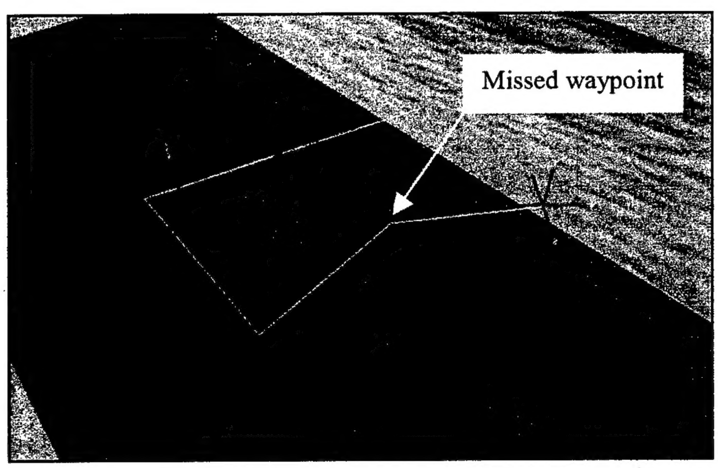

Figure 3. AAV navigation error resulting from a missed waypoint.
Substantial deviation from the designated course leaves the AAV vulnerable to mines.

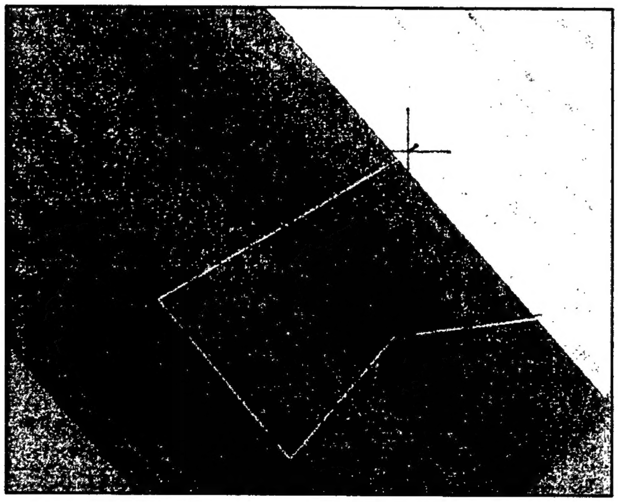

Figure 4. Animation using a plan view perspective.

DISCUSSION

The AAV visualizations depicted in figures 2 and 3 were recently presented at the Oceans '03 Conference (Lohrenz, et al., 2003). Software links were inserted into a PowerPoint presentation to launch the viewer and 3D application at the appropriate time.

The 3D AAV model can be viewed and manipulated separately to convey the physical and visual constraints of the vehicle driver (Fig. 5), or for training and familiarization purposes. For example, the user can rotate the entire vehicle, operate any of its moveable parts (e.g., open the hatches), and even enter the vehicle for viewing from within.

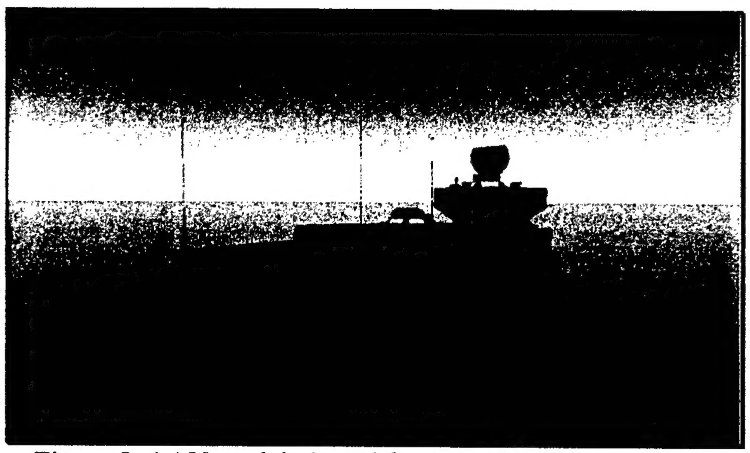

Figure 5. AAV model viewed from a different perspective.

SUMMARY

NRL has developed 3D visualization applications based on VRML and X3D graphics as an alternative means of information presentation. These applications can be displayed with "shareware" viewer software on conventional Internet web-browsers and are equally effectively in oral presentations and in separate

on-line viewing via Internet web-browsers. These applications were developed to visualize Marine Corps AAV navigation performances during field demonstrations. They depict steering patterns used to avoid surface waves, how well the drivers negotiate lane turning points, and a vehicle's vulnerability to potential threats when it is steered outside of the cleared navigation lanes.

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